Concrete Pavement:

Rehabilitation Applications, Options & Performance

Purdue Road School

March 29, 2006

IRMCA
INDIANA READY MIXED CONCRETE ASSOCIATION

Mike Byers

Executive Director

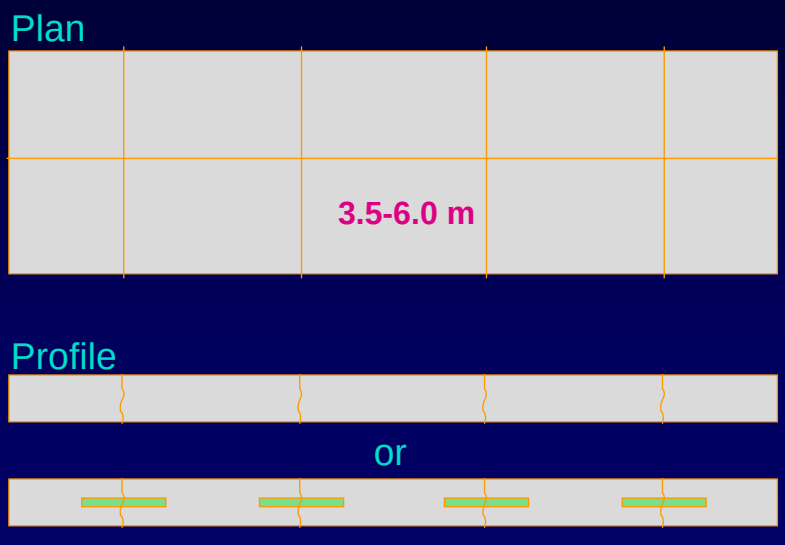
INDIANA CHAPTER ACPA

Concrete Pavement Basics

Concrete Pavement Types

- Jointed Plain
  - Undoweled
  - Doweled
- Jointed Reinforced
- Continuously Reinforced

Jointed Plain

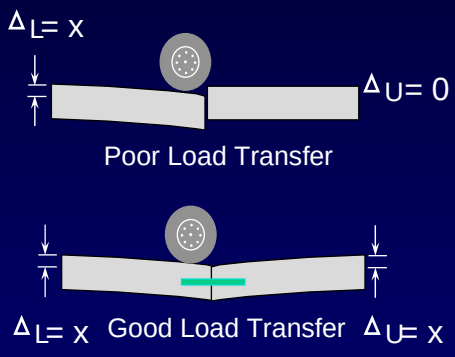


Jointed Plain

Jointed Plain

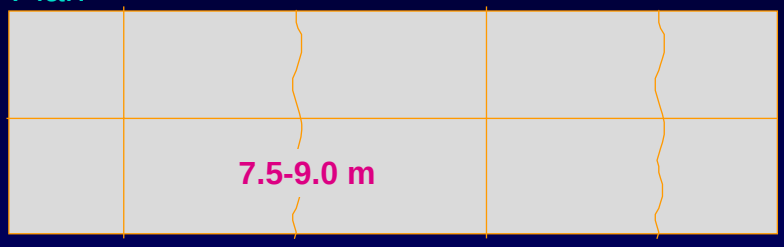
Load Transfer

- The slabs ability to share its load with its neighboring slab
  - Dowels
    High Traffic Volumes
    (Pavements > 8 in.)
  - Aggregate Interlock
    Low Traffic Volumes
    (Pavements < 7 in.)



Jointed Reinforced

Plan

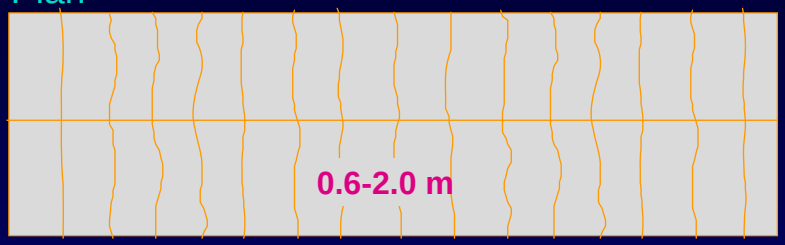


Profile

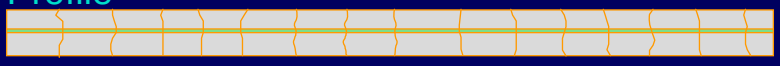
Jointed Reinforced

Continuously Reinforced

Plan



Profile



Continuously Reinforced

Rehabilitation Strategies

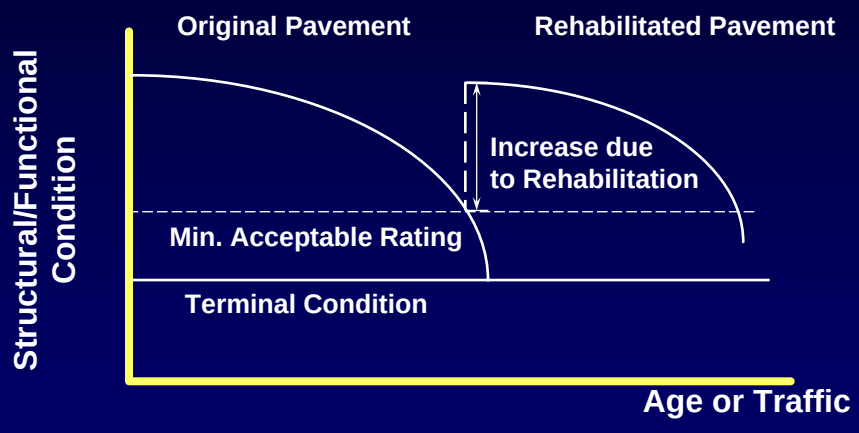
- Three categories:
  - Restoration
  - Resurfacing
  - Reconstruction

    Together, known as CPR[3]
- Which is used depends on existing condition.

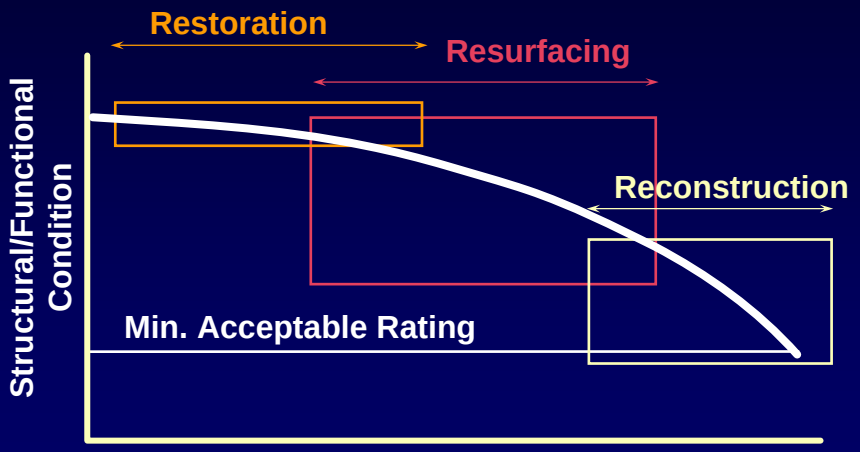
Concrete Pavement Rehabilitation

- Improves structural and/or functional condition of pavement.
  - Structural condition - the ability to carry traffic.
  - Functional condition - the ability to serve the user comfortably.

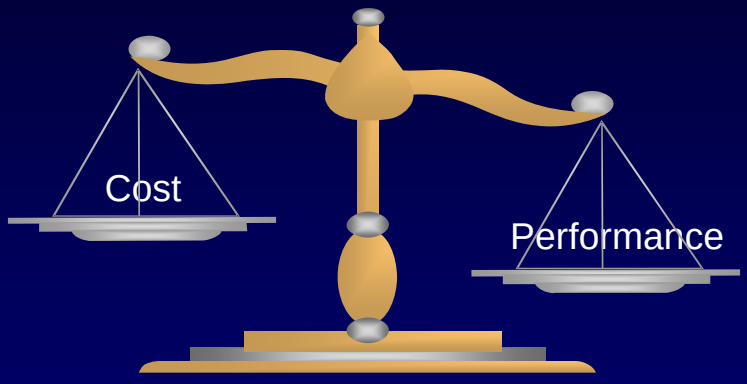
Pavement Condition



Rehabilitation Timing

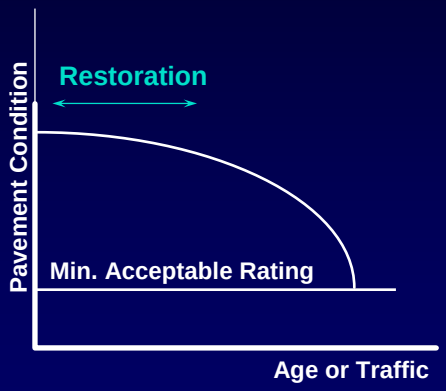


Optimize



Restoration (CPR)

- Used early when pavement has little deterioration.
- Repairs isolated areas of distress.



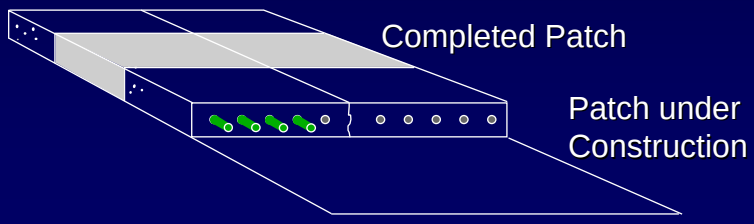
Restoration Techniques

Concrete Pavements

- Full-depth repair
- Partial-depth repair
- Diamond grinding
- Joint & crack resealing
- Slab stabilization
- Retrofitting dowels
- Retrofitting concrete shoulders
- Cross-stitching long. cracks/joints

Full Depth Repairs

- Repairs distresses greater than 1/3 the slab depth.
- Consists of removing and replacing at least a portion of the existing slab to the bottom of the concrete.

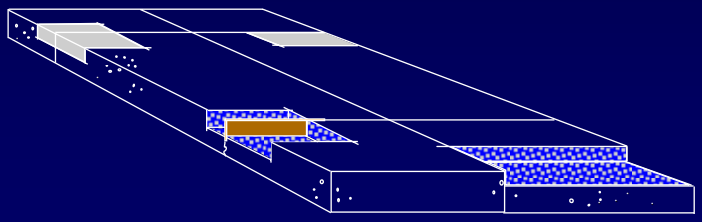


Use of High Early Strength Mixes

- Can design mix to meet opening need requirements
- Specify minimum requirements:
  - INDOT(506.04): Minimum cement – 658 lbs./cy
  - INDOT(506.11): Open to traffic when M_R > 300 psi
  - When use Calcium Chloride – use 506.11 Chart
  - Alternative – can use maturity method to open
- California 4 x 4 system

Partial Depth Repairs

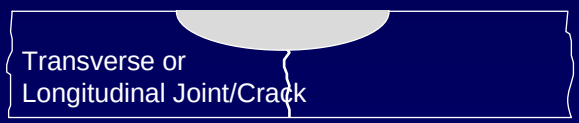
- Repairs deterioration in the top 1/3 of the slab.
- Generally located at joints, but can be placed anywhere surface defects occur.



Carbide-Milling

Longitudinal Milling

Transverse Milling (Half-moon)



TYPICAL SPALLS

REMOVAL

- Milling machine

MILLING IN PROGRESS

TYPICAL MILLED AREA

PDR IN PROGRESS

PDR IN PROGRESS

CURING

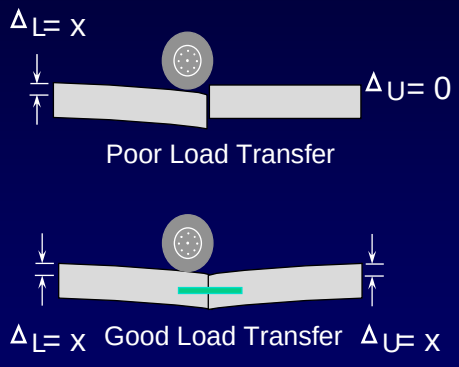
- **Use curing compound**

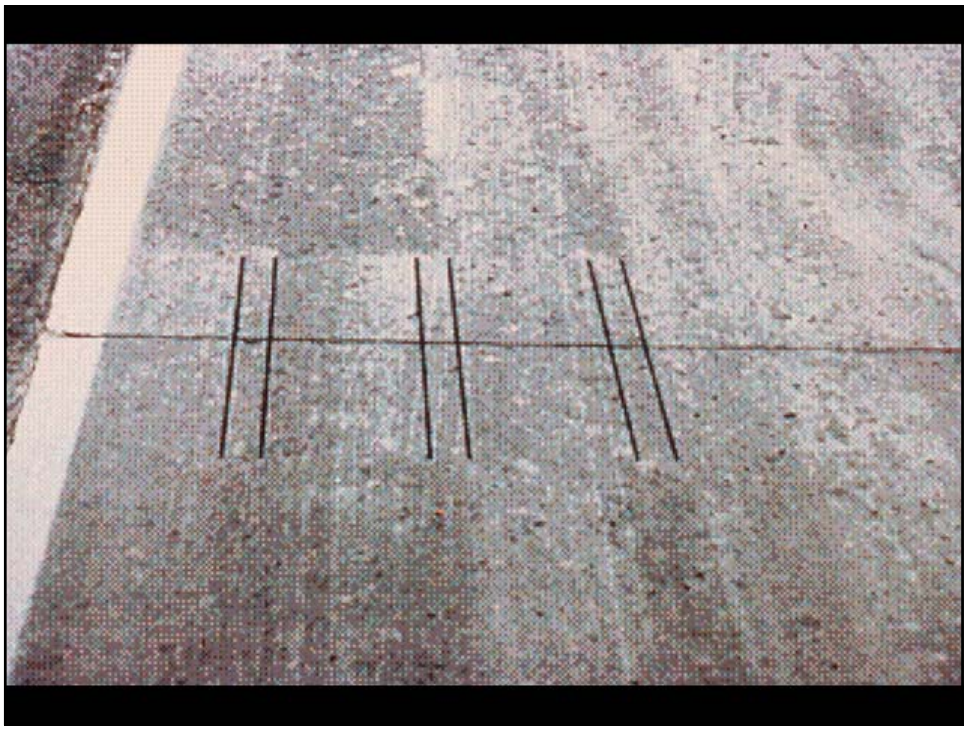
Supporting Research

- JTRP/Purdue research nearing completion with report due summer 2006
  - SPR – 2648: Evaluation of Rapid Setting Cement Based Materials for Patching (Ph I)
  - SPR – 2789: Dowel Bar Retrofit Mix Design & Performance
- Presentation of interim result available on 2006 PCCP Workshop CD
- Field Trial of Rapid Set Materials (Ph II)

Load Transfer Restoration

- Reestablishes load-transfer at undoweled joints or cracks
- Used to limit future faulting






Concrete Pavement Restoration

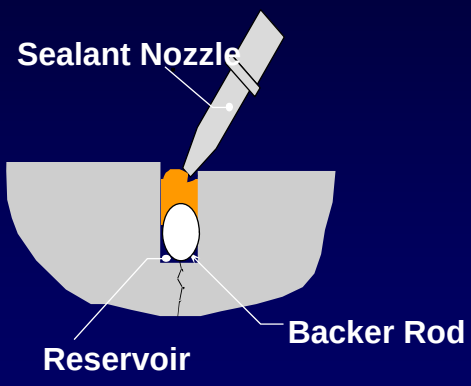
Concrete Pavement Restoration

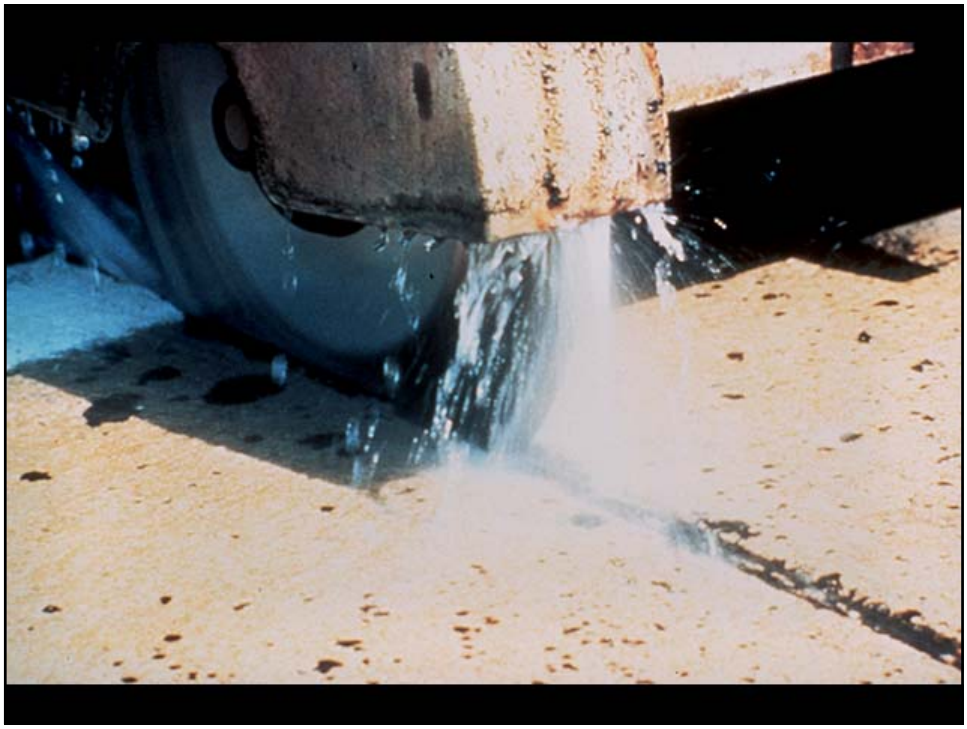
Diamond Grinding

- Improves ride by removing:
  - Faulting at joints
  - Slab warping
  - Surface deformations caused by studded tires
- Reestablishes skid resistance
- Corrects cross-slope

Joint and Crack Resealing

- Minimizes water & incompressibles into pavement system.
  - Reduces:
    - Subgrade softening
    - Pumping
    - Erosion of fines
    - Spalling





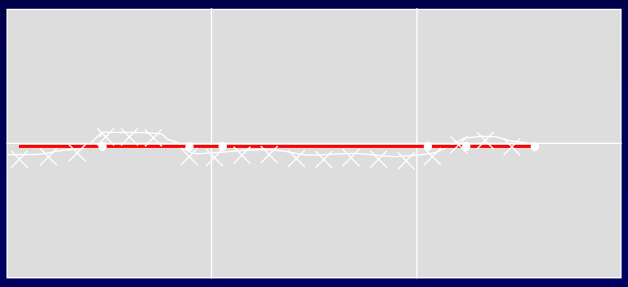
Restoration Performance

- Provides 10 or more years of service.
- Preliminary engineering & timing are critical.
- Overall effectiveness is highly dependent on design adequacy, construction quality, and other restoration activities.

Repairing Cracks

Alternative: Cross Stitch Crack

Recommendation: Saw & Seal Crack - Epoxy Saw Cut



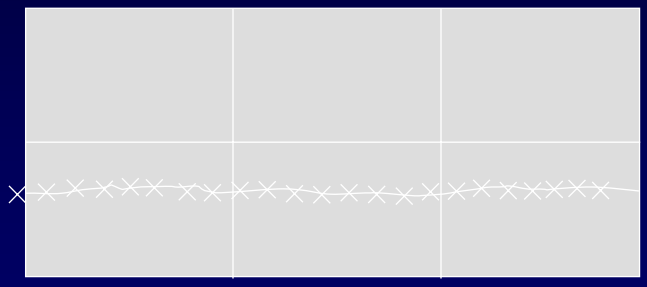
- Crack Fully Penetrates Slab Depth
- Crack within 0.3 m of Joint
- Joints Not Cracked where Cracks Exist

Cross-Stitching

Cross-Stitching

Repairing Cracks

Recommendation: Cross-Stitch the Crack

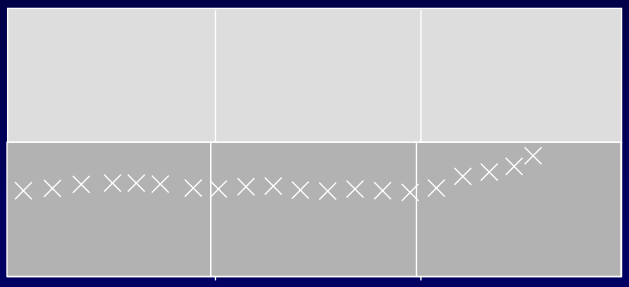


- Crack Fully Penetrates Slab Depth
- Crack Relatively Parallel in Mid-slab (>1.35 m) from Joint or Edge

Repairing Cracks

Alternative: Cross-Stitch Crack

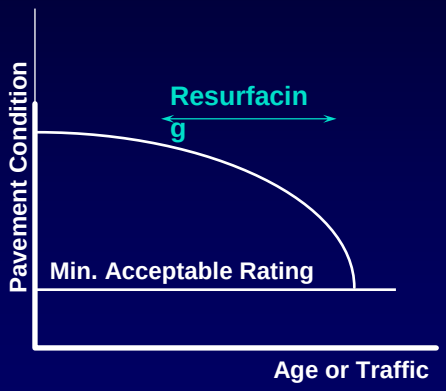
Recommendation: Replace Slabs Full-Depth



- Crack Fully Penetrates Slab Depth
- Crack Relatively Parallel in Wheelpath (0.3-1.35 m) from Joint

Resurfacing

- Used when pavement has medium to high levels of distress.
- Used when restoration is no longer effective.

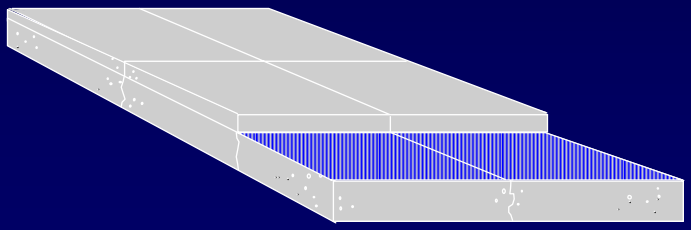


Resurfacing Activities

- Concrete overlays for concrete pavements:
  - Bonded Concrete Overlays
  - Unbonded Concrete Overlays
- Concrete overlays for asphalt pavements:
  - Conventional Whitetopping
  - Ultra-Thin Whitetopping

Bonded Overlays

- Consists of a thin concrete layer (100 mm or less) on top of an existing concrete surface.
- Specific steps are taken to bond the new concrete overlay to the existing concrete.



Bonded Overlays

Bonded Overlay

- The major use of Bonded Overlays is structural enhancement of the pavement.
- Cracks in the underlying pavement will reflect into the resurfacing
- Most often used where the underlying pavement is in reasonably good condition.

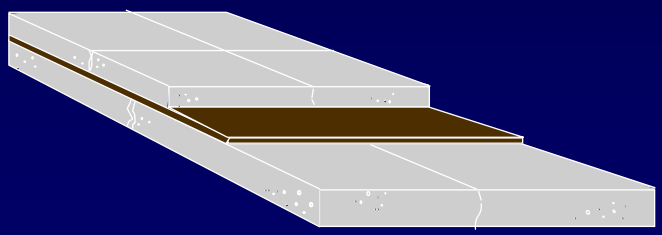
Bonded Overlays

Performance

- Good when:
  - Placed correctly and at the right time.
- Poor when:
  - Placed on deteriorated pavements.
- Loss of bond does not necessarily constitute failure.

Unbonded Overlay

- Consists of thick concrete layer (125 mm or greater) on top of an existing concrete.
- Uses a “separation interlayer” to separate new overlay and existing concrete.



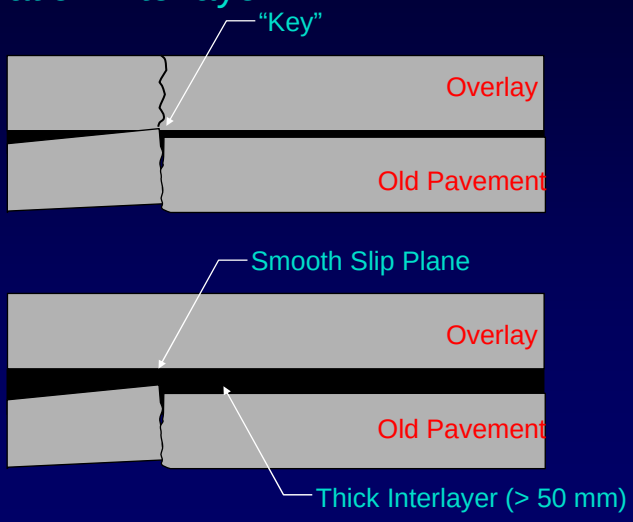
Unbonded Overlays

Separation Interlayer:

- Allows layers to act independently.
- Prevents distresses from reflecting into overlay.
- Typical Interlayer:
  - 1-1 ½ “ Asphalt layer

Unbonded Overlays

Separation Interlayer:



UNBONDED CONCRETE OVERLAYS

Advantages

- Can Place on Pavement in Bad Condition.
- Less Pre-Overlay Repair Needed Than Other Overlay Designs.
- No Future Reflective Cracking.
- Avoid Reconstruction Problems.
- Maintain Traffic.

UNBONDED CONCRETE OVERLAYS

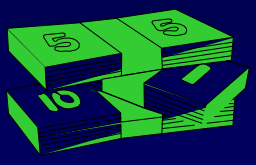
Job-Site Considerations

- **Overhead Structures.**
- **On-line Bridges.**
- **Shoulders.**
- **Fill for Slope Flattening.**
- **Traffic Control.**

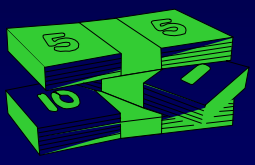
UNBONDED CONCRETE OVERLAYS

Payment

Cubic Yard



Square Yard



NOTE: Divided payment is the most equitable and economic.

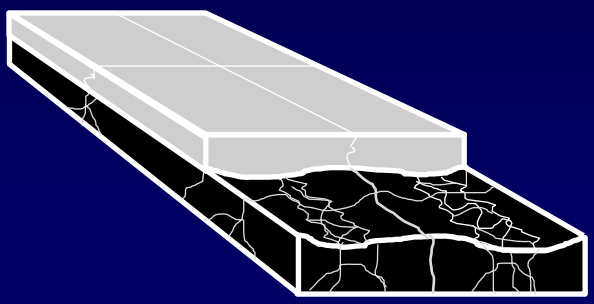
Unbonded Overlays

Performance

- Very Good
- Can be expected to perform for 20+ years.
  - Most failures are due to the use of inadequate separation layers.

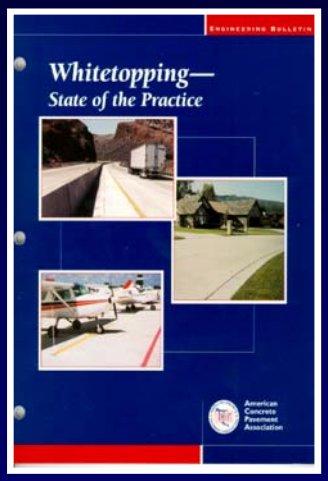
Conventional Whitetopping

- Consists of thick concrete layer (100 mm or greater) on top of an existing asphalt pavement.
- Behaves as a new pavement on a strong base.



Whitetopping Engineering Bulletin

- New for 1998
  - Conventional Whitetopping
    - Design
    - Construction
    - Performance
  - Ultra-thin Whitetopping
    - Design
    - Construction
    - Performance



Whitetopping - History

- First Whitetopping
  - South 7th street in Terre Haute, Indiana - 1918
  - 4" concrete overlay of existing asphalt pavement
- During 40's & 50's used to upgrade military & civilian airports
- Highway use started approx. 1960
  - Types have included JPCP, JRCP, CRCP, FRC

Whitetopping History

- Modern usage began in Iowa in 1960's where heavy loads from farm trucks created a need for a durable pavement.
- Performance was excellent
- Over 500 miles of whitetopped roads since the 1960's
- Now used for Interstates, highways, airports, intersections and parking lots

Typical Whitetopping Thickness

- Depends on expected traffic load.
  - City streets, county roads, and small airports
    - 100 to 175 mm (4 to 7 in.)
  - Primary roads and interstate highways
    - 175 to 280 mm (7 to 11 in.)
  - Large airports
    - 200 to 460 mm (8 to 18 in.)

Whitetopping - Advantages

Construction

- Can place on pavement in bad condition.
  - Little or no pre-overlay repair needed.
- Avoid reconstruction problems.
  - Minimal rain delays.
  - Maintain traffic on existing surface.

Whitetopping - Advantages

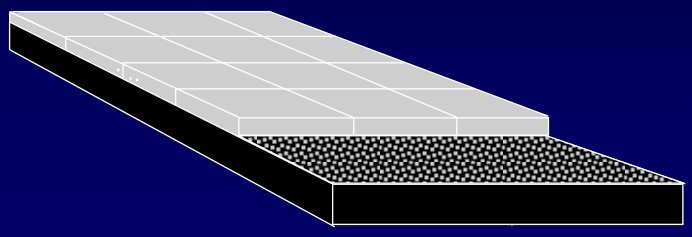
- Improved structural capacity.
- Maintains high level of serviceability.
- Low maintenance.
- No seasonal weakening (spring breakup).
- Concrete slabs bridge problems asphalt cannot.
- Light reflective, safe riding surface.

Whitetopping Construction

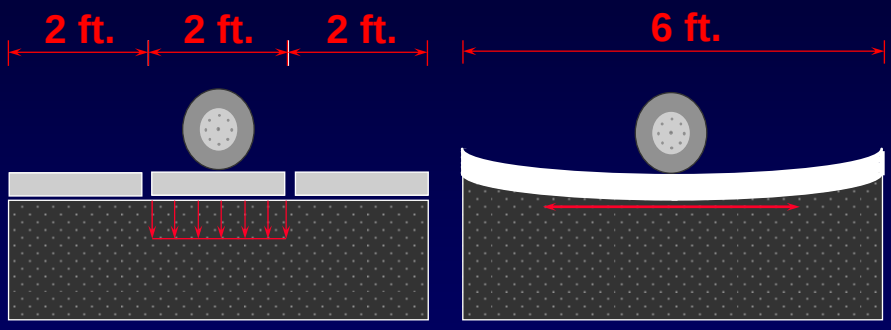
- Critical issue is uniform support
- Subgrade / base failures need repair
- Need to evaluate drainage (esp. Inlays)
- Address surface distortions
  - Direct application
  - Profile milling
  - Leveling course

Ultra-Thin Whitetopping

- Consists of thin concrete layer (4 in. or less) on top of an existing asphalt pavement.
- Specific steps are taken to bond the new concrete to the existing asphalt and to saw short joint spacing.

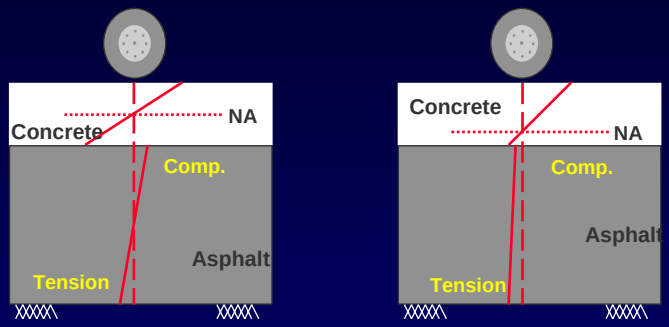


Ultra-Thin Whitetopping



Short joint spacing allows the slabs to deflect instead of bend. This reduces slab stresses to reasonable values.

Bonding Effects on Edge Stress



Unbonded	*Bonded*
8.49 Mpa (1230 psi)	2.90 Mpa (420 psi)

75 mm Concrete, 100 mm AC, K=81 Mpa/m, Ec = 27,580 Mpa, Eac = 2,758 MPa

Known Design Considerations

- Bond is critical.
- Slab size (Jointing) is important.
- Underlying asphalt thickness is important.

OVERLAY PERFORMANCE in INDIANA

Specific Concrete Overlay Projects

Indiana Overlays

- I – 69 North of SR 18 – 11” 1986
- I – 65 North of SR 114 – 10.5” 1994
- 1 – 94 West of SR 39 – 13” 1998
- I – 70 at US 27 – Richmond – 12” 2000
- Harding Street – Indianapolis – 6” 1985
- 121st Street – Fishers – 9” 1992
- Indianapolis Bus Lanes – 3.5” 1997
- Allisonville Rd – N. of 96th – 7” 1999
- 56th Street – Brownsburg – 5” 2001
- Market & Columbia – Warsaw – 3.5” 2002

I-69 UNBONDED PCC OVERLAY

FROM SR 18 RM 66.29

to

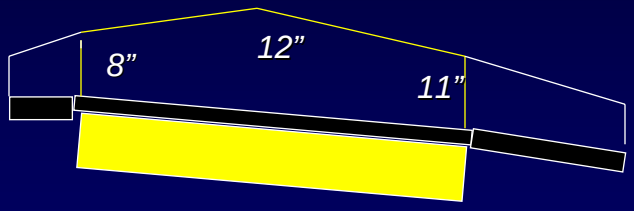
GRANT COUNTY LINE RM 71.64

I-69 UNBONDED PCC OVERLAY

- OPENED TO TRAFFIC 1964
- RESURFACED (Bituminous) 1975
- NBL RESURFACED (Bituminous) 1978
- UNBONDED OVERLAY 1986

I-69 UNBONDED PCC OVERLAY

I-65 UNBONDED PCC OVERLAY



Harding Street - Indianapolis

- Old concrete street with patches
- PCC Unbonded overlay placed 1985
- 6” thick over old street
- Widened 6’ with 8” PCCP
- Skewed non-doweled transverse joints
- Tied longitudinal joint provided at section thickness change
- Still in excellent condition

Harding Street - Indianapolis

Harding Street - Indianapolis

Harding Street - Indianapolis

Harding Street - Indianapolis

121st Street - Fishers

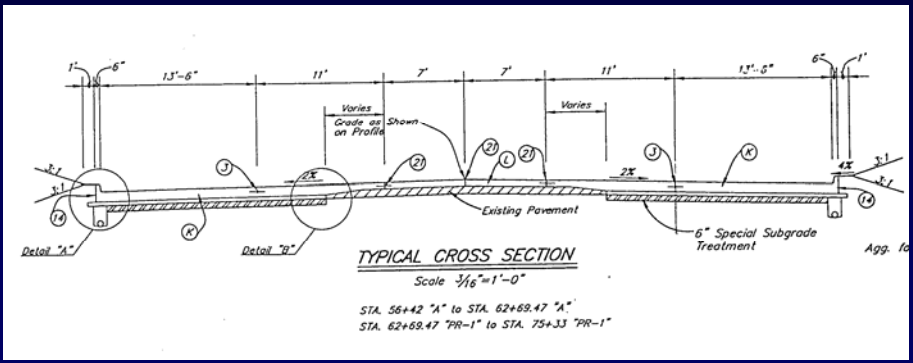
Allisonville Road

96th Street to Eller Road

Project Information

- Traffic: 26,360 vpd
- Existing 24’ asphalt pavement
- Scope:
  - widen to outside
  - maintain traffic
  - mill & overlay existing

Allisonville Road Cross Section



Allisonville Road

56th Street - Brownsburg

- Commercial and Residential traffic
- 44’ wide, 3500’ long
- 6” concrete overlay with variable depth to 9” as needed
- Center line realignment
- Drainage
- Texture: Turf Drag and Random Tining

56th Street Brownsburg

56th Street Brownsburg

City of Indianapolis

Ultra – thin Whitetopping

Bus Lanes

PLACING CONCRETE

PERFORMANCE

- All three sections are performing well

Market & Columbia Streets - Warsaw

Market & Columbia Streets - Warsaw

3 ½” Concrete overlay over milled HMA
Joints sawed at maximum spacing – 5’– 0”
Joints sawed at 1/3 depth of overlay

Market & Columbia Streets - Warsaw

Market & Columbia Streets - Warsaw

Market & Columbia Streets - Warsaw

Madison, IN Airport Apron

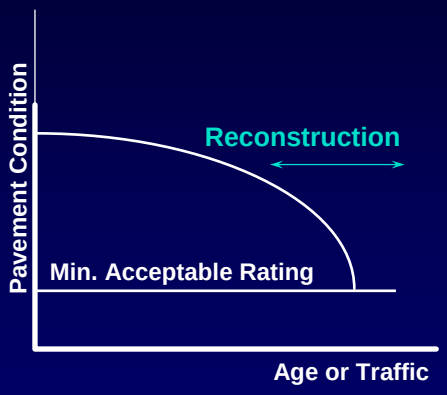
3 ½ " Concrete overlay over existing HMA

Joints sawed at 4' x 4' spacing

Madison, IN Airport Apron

Reconstruction

- Used when the pavement has high levels of distress.
- Used after overlays are no longer effective.



Reconstruction Activities

- Final stage of rehabilitation.
- Involves removing and replacing existing pavement with a new pavement.
  - Complete removal & replacement
  - Partial removal & replacement (Inlay).
- Can correct:
  - Subgrade / subbase deficiencies, Roadway geometrics, Roadside safety features, Drainage

Reconstruction Activities

- Controls the final elevation
  - Minimizes roadside appurtenances adjustments.
- Can recycle the old pavement

Summary

- CPR^3 repairs structural / functional deficiencies.
- Improves pavement condition to an acceptable level.
- Appropriate activity depends on the existing pavement condition.
  - As condition declines, the optimum activity changes.
  - Applying correct activity at correct time is essential.

Summary

- Restoration
  - Repairs isolated areas of deterioration.
- Resurfacing
  - Repairs a pavement with medium to high severity levels of distress.
- Reconstruction
  - Used at the end of the pavement's life, when it has very high severity levels of distress.

YOU HAVE OPTIONS.

Questions?

www.pavement.com